

Cost-Effective Health Information Systems: User-driven Internal Development at the University of Iowa

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ABSTRACT

Goals: *The Information Network For Online Retrieval & Medical Management (INFORMM), health information system (HIS) for the University of Iowa Hospitals and Clinics (UIHC), was analyzed with regard to development of a Computer-Based Patient Record (CBPR) in a cost-effective manner¹.*

The analysis: i) profiles INFORMM system functionality; ii) displays INFORMM use and satisfaction among physicians, nurses, and other hospital employees; iii) characterizes dynamics affecting INFORMM growth; and iv) evaluates the cost of a system of internal-development of software.

Data sources: *INFORMM utilization for 1989, 1994, and 1995; service requests from users for the years 1985, 1990, and 1994; 1994 MECON-PEERx data; gap analysis user survey conducted by an independent consulting firm.*

Main Results: *1) Physician use has been dominated by a single function: retrieval of laboratory results. 2) Nurse use of the system was more diverse. A recent surge of nurse and physician use resulted from the introduction of online documentation of nursing care². 3) Overall use has been predominantly by non-clinician users, no one function dominating their pattern of use. 4) User service requests were predominantly from the non-clinician group of users. Requests from non-physician groups have been coordinated by a limited number of representatives of those groups, unlike requests from physicians. 5) The UIHC HIS ranked high in user satisfaction. 6) The overall cost of the UIHC HIS system is relatively low as a percentage of the gross operating budget or as a ratio to the volume of patient activities in this medical center.*

Conclusions: *Internal development of INFORMM has been a cost-effective solution to the information demands of nursing staff and other users. INFORMM system composition reflects the quantity and organization of user requests. Satisfying the needs of physicians requires a change in the manner in which physician needs are assessed.*

INTRODUCTION

The UIHC information systems department (ISD) developed a collection of applications, known as *INFORMM*, that consists of seventy-five internally-

developed and five vendor-developed applications. *INFORMM* supports all departments of the UIHC, usually as their primary computer system or, in a few cases, as the central data repository for a vendor system.

All computer-based information is available through a single interface. Users can access appropriate information from any terminal throughout the medical center. Such integration results from the fact that most of the applications are developed by the UIHC ISD. Thus, the UIHC ISD has avoided the problem many ISDs have faced of integrating a number of disparate systems³.

Does *INFORMM* meet the criterion that a system should evolve to suit the demands of its user groups^{1,4}? This report examines the correspondence among: a) the number of service requests, b) the number of functions available, and c) the utilization of applications, when stratified by user group (physicians, nursing staff, and others).

In presenting this study on the nature and cost of developing and maintaining the *INFORMM* system, we will challenge the implicit, or sometimes explicit, assumption that the only cost-effective approach involves purchasing software produced by commercial vendors^{3,5,6}, or the converse assumption that it must be more costly for an institution such as the UIHC to develop its own software. Factors that may contribute to the cost-effectiveness of HIS are discussed.

SETTING

The UIHC, Iowa City, IA, (pop. ca 50,000) has 881 beds, over 35,000 admissions, and over 480,000 clinic visits per year. The distribution of UIHC staff and *INFORMM* system users among physicians, nursing staff, and others demonstrates nearly all personnel are system users (Table 1).

The central data repository is a hierarchical database in which there are over 1.7 million patient records and more than 210.5 gigabytes of patient-related data (Table 1).

The transaction rate, i.e., the number of screens of data that are presented per day, is nearly 1.5 million with an average elapsed time of 0.14

Table 1. Profile of the UIHC and its HIS (1995).

Number of Beds	881
Outpatient visits/yr.	>483,000
Inpatients/yr.	>35,000
Personnel:	
Total	7,624
Physicians	1,320
Nursing staff	1,560
Other	4,744
No. of System Users:	
Total	7062
Physicians	1279
Nursing staff	1560
Other	4223
Mainframe Processor	IBM 3090-500J
Terminals	1,648
No. of Patient Records	1.7 Million
Database Size	210.5 Gb
No. of Transactions/day	~1.5 million
Avg. Response Time (sec)	0.14
Availability (% of time)	99.12

seconds between the request and the data screen. The *INFORMM* system is available 99.1% of all time, including time for scheduled maintenance (Table 1).

Most applications in the *INFORMM* system were developed using a fourth generation application development tool: ADS Plus. The entire set of 80 applications allows users to choose among 2,291 separate functions. The breadth of functions covered by four application areas is outlined (Table 2).

The system restricts users' access to functions appropriate to their respective jobs. The patient population to which users have access is limited. Therefore, the comparisons to be made are the relative use of specific functions within each group and the transaction rates between groups.

Utilization was studied for three periods: October of 1989, October of 1994, and March of 1995. The data were for utilization during weekdays (Monday - Friday) of those periods. Service request data were for the years 1985, 1990, and 1994, spanning a broader period because utilization reflects the response to user requests of the years preceding.

RESULTS

Patterns Of Growth

The rate of *INFORMM* use per individual within each user group factors out variability due to the number of users in each group (Table 3). Non-clinical users (row 4) are heavier *INFORMM*

Table 2. Profile of *INFORMM* Applications.

Clinical	Administrative
Diagnostic Results	Scheduling
Treatment & Registry Protocols	Visit Tracking
Pharmacy	Care Management
Clinician Documentation:	Quality Improvement
Online Nursing Orders	Resource Utilization
Selected Physician Notes	Medical Records
Financial	Technical Operations
Patient Accounting	Security
General Ledger	Systems
Statistics	Databases
Financial Reporting	Operations
Budget Support	Telecommunications
Materials Management	Networking

users than are: the average (row 1), physician (row 2), and nursing staff (row 3) users. Faculty physicians use the system much less than resident physicians. Use among orthopedics and neurology nursing staff was heavy as a result of implementation of online nursing documentation in those settings². Use of *INFORMM* was heaviest, by far, among those in the business office and in registration.

The functions most used by physicians, nursing staff, and others in 1989 and 1994 show some interesting patterns (Table 4). Physician use of the system was dominated by the use of a single function to retrieve "Lab Results" in both 1989 and in 1994. For other groups, use of functions among the top ten was more evenly distributed. The function to retrieve "Messages" has become the most used function for nursing staff.

User Driven System Development

The distribution of *INFORMM* utilization by user groups as a whole is shown (Figure 1A) for purposes of comparison to the number of service requests from these same groups (Figure 1B). In 1995, physicians and nursing staff accounted for only 25% of all *INFORMM* transactions. The proportion of service requests that have come from physicians and nursing staff over ten years was 26%. The proportion of clinical functions, 28.5% (653 of 2,291), may be viewed as a response to the perceived demand.

Despite the larger number of service requests from physicians than from nursing staff, use of *INFORMM* has been higher by the latter. Physician requests differed in that they were submitted by a relatively large number of individuals (average of two requests per person). Requests from others were submitted by relatively few individuals (average of seven requests per individual). Requests

Table 3. INFORMM Utilization per Day per User.

	Group Description	1994	1995
1	All Users	190	215
2	Physicians	56	71
3	Nursing staff	77	100
4	Others	307	329
	Physicians:		
5	Faculty physician	37	50
6	Resident/Fellow	83	100
7	Student physician	41	50
8	Other physician	30	74
	Nursing staff:		
9	Critical Care	52	54
10	Medical	89	107
11	Obstetrics & Gynecology	43	77
12	Ortho./Neuro./EENT/GU	162	170
13	Pediatric	48	77
14	Perioperative	93	86
15	Surgical/CCC	80	100
16	Other	83	113
	Others:		
17	Business office	1410	1482
18	Clinical services	258	273
19	Medical records	629	624
20	Registration	1025	1036
21	Support services	174	186
22	Other	67	78

from non-physicians are coordinated by a few individuals who represent their departments. This has not been the case for physicians. A large number of the requests from physicians are for data for clinical research projects and, therefore, do not result in system enhancements that increase the interactive use of the *INFORMM* system by physicians.

User Satisfaction

In 1992, the UIHC ISD participated in a gap analysis of user opinions along with another large medical center and three other industries with investment in information systems. The study, conducted by an independent consulting firm funded by non-UIHC sources, used interviews and written surveys to poll users within the institutions. Those polled at the UIHC included 4 physicians, 3 nursing staff, and 22 from other user groups. Users were asked to rate the importance of categories and to rate how well the ISD was performing in each category. All of the five ISDs were rated fairly highly by their respective users in most categories. The UIHC ISD

Table 4. Functions by Percentage of All Transactions for the Indicated Group.

1989		1994	
Physicians	%	Physicians	%
Lab Results	52.9	Lab Results	40.5
Sign On	12.3	X-Ray Results	7.0
Lab Profile	10.9	Sign X-Ray Exam	6.4
Messages	4.8	Micro Results	6.0
Result Master	3.7	Sign On	5.0
Path. Results	2.8	Messages	5.0
Visits	1.7	Lab Profile	4.5
Result Master	1.4	Result Master	3.8
Patient By Name	1.3	Patient Visits	2.6
Patient Basic Data	1.2	Path. Results	2.3
Nursing staff		Nursing staff	
All Orders 8 hours	15	Messages	10.7
Lab Results	8.7	Verify Orders	9.2
Sign On	7.5	Lab Results	6.5
Add/Update Orders	9.3	Send A Message	6.1
Orders - All Patients	4.0	Add/Update Orders	4.1
Update Care Plan	3.3	Chart Orders	4.0
Messages	2.9	Sign On	3.7
Update Diet Tray	2.1	Cafeteria Menus	2.1
Nursing Diagnosis	2.1	6-wk Work Schedule	1.9
Update Unit Lists	2.0	Update Care Plan	1.9
Others		Others	
Billing Notes	11.7	Billing Notes	7.1
Add Service Activity	3.7	Messages	4.5
Patient Payer Data	2.8	Retrieve Med Rec Loc	3.5
Update Appointment	2.6	Update Med Rec Loc	3.0
Hospital Claims	2.6	Send Message	2.9
Sign On	2.4	Retrieve Appointment	2.4
Retrieve Appointment	2.3	Schedule Appointment	2.2
Display Phys. Pymts.	2.2	Add Service Activity	1.9
Display Hosp. Pymts.	2.1	Hospital Claims	1.9
Patient Basic Data	2.0	Patient Visits	1.6

received the highest performance ratings in five of the six categories (addressing strategic issues, delivering quality systems, developing positive communication, delivering quality information, delivering training and support). In the remaining category, the UIHC ISD was rated second (timeliness of application development).

This survey indicated a high degree of overall satisfaction among *INFORMM* users. The high volume of use and large number of users of the system would tend to support this impression. However, the distribution of those polled reflected

Figure 1A. Transactions by Group

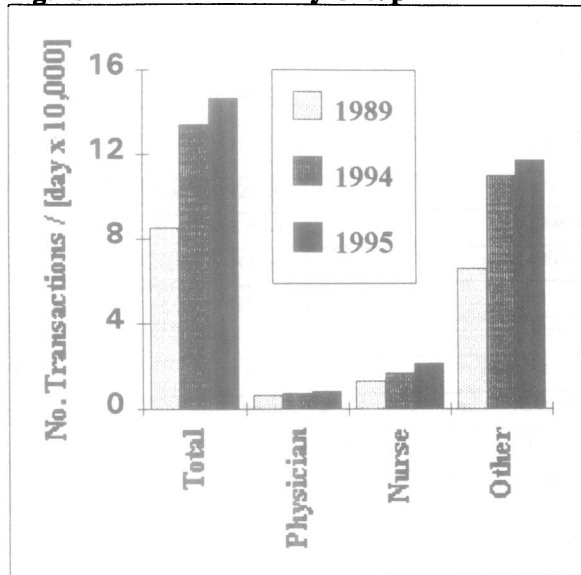
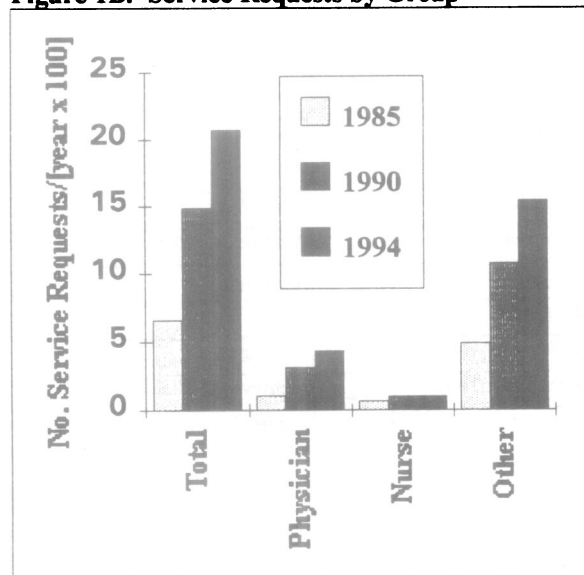


Figure 1B. Service Requests by Group



the distribution of system use, representing a comparatively small number of physicians.

Informal evaluation suggested common sources of dissatisfaction with *INFORMM* among physicians. One common physician criticism was that *INFORMM* does not automate many common clinical activities now done manually such as transcribing into physician notes information that is available in *INFORMM*. Other clinical information that physicians capture routinely in their documentation is not captured in *INFORMM*.

Another point of criticism was that the *INFORMM* database is not easily queried for research purposes. The hierarchical database

Table 5. Performance among MECON-PEERx institutions using internal development of HIS.

Category	UIHC	25th	median	75th
Discharges (Dsch)	40,475	15,140	22,888	30,965
Applications	80	36	46	89
vendor dvlpd.	5	11	15	25
internally dvlpd.	75	10	21	67
No. of FTEs	71.6	28.9	47.5	53
Jobs / day	1,301	0.3	410	739.7
HIS expense: % of total budget	1.2	1.2	1.7	1.9
Cost \$ / 100 Dsch	12,001	10,500	14,117	19,866

requires that research-related queries be handled by programmers trained in a specialized programming language. Hence, there is the perception among physicians that the ISD maintains a monopoly on the information contained within *INFORMM*.

Comparative Cost of HIS

Among medical centers belonging to the MECON-PEERx group, a voluntary association of medical institutions that share self-descriptive data for performance comparison, a wide variety of solutions are applied to the problem of collecting, storing, and distributing information. The UIHC was compared to other centers that use internal development of HIS (Table 5). Even within this group, the UIHC HIS has an unusually high proportion of applications that were internally developed. The UIHC is relatively large in comparison to the other centers.

In judging relative cost-effectiveness, one compares qualitatively similar systems by their relative costs¹. The cost information reflected in the data (Table 5) included software (acquisition, development, and maintenance), consultant fees, and hardware maintenance. The UIHC ISD budget was relatively low as a fraction of the total operating budget (Table 5). When capital costs of hardware are included, the UIHC ISD budget is 1.8% of the total budget, still low compared to the 2.5% figure for the average medical center^{5,7}.

DISCUSSION

The profile of applications available in *INFORMM* is comparable to those available in other large medical centers⁵. The composition of *INFORMM* is a direct reflection of the organized presentation of user demand. User satisfaction levels compared favorably with other institutions. On the other hand, compared to other medical centers, the cost of the UIHC HIS was low as a percentage of medical center budget. Based on these facts, and upon published

criteria for cost-effective HIS^{1,5}, we conclude that internal development can be a cost-effective option.

It may be true that this conclusion is relevant only to large medical centers. However, the facts do contradict a commonly held perception that internal development is always relatively expensive.

Purchase of vendor-developed software is thought to be a cost-effective choice for reasons that are obvious: one vendor can supply a large number of users with the same needs. However, while the needs of medical center users are similar, they are not exactly the same. Vendor-developed HIS software must be tailored to suit local use, requiring thousands of separate decisions and often several years to implement. Internal development has a competitive advantage in this regard in that tailoring for the medical center occurs along with the design of the applications.

Are medical centers more different than they are alike with regard to their information system needs? The extensive local effort needed to implement vendor packages suggests that, at present, diversity is the rule. This may change as medical care is subject to tighter scrutiny, more rules, and economic pressure. However, it is by no means certain that these forces will cause the needs of medical centers to become more uniform, rather than less.

A second advantage of internal development occurs when a medical center expands or restructures. Vendor software is not owned by the medical center. It is licensed for use at each site for a given number of users. Internally developed applications are available to new sites and new users without incurring additional software costs.

A different problem occurs when an institution uses the "best-of-breed" approach to buy separate applications to suit various needs³. Integration of information among the various medical center departments becomes increasingly important for reasons that are clinical, economic, and imposed by government or third party payers. While standards for communication among systems continue to evolve, ISDs that maintain a number of vendor applications expend their efforts in maintaining interfaces among those applications. That effort is continuous because each vendor issues updates to software on a regular basis.

There are reasons that even an internally developed HIS should take advantage of the growing trend toward "open systems", a term that has many possible meanings, depending on the situation. One initiative at the UIHC is a transition to a relational database to allow research users to query the

database. A second initiative is the transition to a client-server architecture to provide users with the desirable features of a graphical user interface⁸, while making available to these users the same database that is available using character-based terminals. In addition, automated transfer of information from the *INFORMM* database to a microcomputer word processor will address another of the problems noted above. The planned architecture will preserve a centralized patient data repository, allowing continued use of security and integrity systems that are in place.

We believe that a CBPR will require that the physician use the computer as the primary information tool. The above initiatives will assist in this process. Another ongoing approach is the creation of a mechanism to coordinate the clinical and research computer needs of physicians, to define the elements needed to support a transition to the CBPR, and to adapt the *INFORMM* system to meet those needs⁸. Based upon the evidence presented, that the *INFORMM* system is a creation of the organized demands of its users, we expect the *INFORMM* system will evolve to meet the needs of a CBPR in a cost-effective manner.

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